OPTIMIZED CELL CONFIGURATIONS FOR STABLE LSCF-BASED SOLID OXIDE FUEL CELLS

STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY-SPONSORED RESEARCH AND DEVELOPMENT

This invention was made with Government support under Contract DE-FC2602NT41246 awarded by the U.S. Department of Energy. The Government has certain rights in the invention.

BACKGROUND OF THE INVENTION

Lanthanum strontium cobalt iron oxides (La(1-x)SrxCoyFe1-yO3-fÔ; LSCF) have excellent power density (>500 mW/cm2 at 750° C.). However, the use of these materials in solid oxide fuel cell (SOFC) applications has been hindered because of various problems associated with the degradation in power with time. What is needed therefore is a cell configuration that enables the use of these materials while minimizing the degradation typically associated with the use of such materials. The present invention meets these needs.

Additional advantages and novel features of the present invention will be set forth as follows and will be readily apparent from the descriptions and demonstrations set forth herein. Accordingly, the following descriptions of the present invention should be seen as illustrative of the invention and not as limiting in any way.

SUMMARY OF THE INVENTION

The present invention is a cathode made from a high power SOFC cathode materials possessing thermal expansion mismatch with a adjacent material. Lanthanum strontium cobalt iron oxides (La(1-x)SrxCoyFe1-yO3-fÔ; LSCF) have excellent power density (>500 mW/cm2 at 750° C.). The biggest problem associated with use of these materials for SOFC applications is the degradation in power with time. We found that the degradation rate of the LSCF cathode is closely related to the cell configuration and metallization as well as firing conditions, which influences the electrical conductivity and oxygen supply to the cathode.

This degradation problem can be remedied by the placement of a fully covered metallization layer on a lanthanum strontium cobalt iron oxide cathode layer within the SOFC. This metallization layer is preferably made from a noble metal and their alloys. In particular embodiments those containing silver and silver alloys such as silver-palladium have been deemed effective. Other materials, including ceramics such perovskites (similar to cathode materials), can also be utilized. Thickening of the cathode, the preparation of the device by utilizing a firing temperature in a designated range and the use of a pore former paste having designated characteristics and combinations of these features provide a device with enhanced capabilities.

In one embodiment, a cathode for use in a solid oxide fuel cell has a metallization layer covering more than 90 percent of the cathode. In some embodiments this cathode includes at least one lanthanum strontium cobalt iron oxide. This cathode may have a porosity of between 0-30 volume percent, thickness ranging from between 2~80 μm or both. Preferably the metallization layer has a thickness of between 10 and 25 percent of the thickness of the cathode. The cathode may be formed by heating a paste at a temperature between 950~1100° C. This paste may have a pore former having 0~30 vol % with respect to the volume of LSCF in the cathode forming paste.

In some embodiments of the invention, various microcracks are created in the cathode. These microcracks are typically formed during the heating process (firing) and can be influenced by a variety of factors. These include the thickness of cathode (the thicker, the more cracks), the firing temperature (the higher, the more in the range described in the patent), the pore former (the less, the more), the character of the cathode paste (the finer, the less), the tap density of powder (the higher, the more), etc.

Full coverage of a metallization layer assists to insure the current collection of the cathode with microcracks. However in some embodiments, overall full coverage has shown a better stability even without microcracks. Cathode porosity is continuous pores throughout the cathode layer. It is interconnected in a fine scale. The microcracks refer to discontinuity in the cathode layer. The cracks are usually perpendicular to the surface of the cathode, forming islands of cathode on the interlayer. The size of cathode islands (spacing between microcracks) is typically between 100~200 micron. However, in some circumstances these microcracks can be significantly sharper and sometimes be within tens of microns.

Various advantages and novel features of the present invention are described herein and will become further readily apparent to those skilled in this art from the following detailed description. In the preceding and following descriptions, only the preferred embodiment of the invention has been shown and described, by way of illustration of the best mode contemplated for carrying out the invention. As will be realized, the invention is capable of modification in various respects without departing from the invention. Accordingly, the drawings and description of the preferred embodiment set forth hereafter are to be regarded as illustrative in nature, and not as restrictive.

DESCRIPTION OF THE DRAWINGS

FIG. **1** shows the typical cell configuration of anode-supported LSCF-based SOFCs.

FIG. **2** shows a comparison of electrochemical performance with different metallization layers.

FIG. **3** shows the effects of cathode thickness on the stability of the LSCF cells with fully covered metallization.

FIG. **4** shows the effect of firing temperature of the cathode layer.

FIG. **5** shows the effect of varying the amount of pore former in the paste and the increasing the stability of fully covered LSCF cells.

FIG. **6** shows the long term performance of a fully covered LSCF cell.

FIGS. **7*a*** and **7*b*** show micrographs of (a) a degraded cell and (b) a stable cell.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The following description includes the preferred best mode of one embodiment of the present invention. It will be clear from this description of the invention that the invention is not limited to these illustrated embodiments but that the invention also includes a variety of modifications and embodiments thereto. Therefore the present description should be seen as illustrative and not limiting. While the invention is susceptible of various modifications and alternative constructions, It should be understood, that there is no intention to limit the